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WOOD DECAY IN ORCHARD TREES

By WILLIAM TITUS HORNE

Much study has been given to the rots of timber, both before and after it is cut, but the decays of orchard trees apparently have never been thoroughly investigated.

During the winter of 1913–14, Mr. C. J. Rodgers, one of our students, discovered that the so-called sappy bark disease of apples is due to a wood rot. This disease is one of the most serious affecting the life of apple trees in California. Slow-working, and only attacking here and there a tree with large wounds, it nevertheless causes tree after tree to weaken generally and break down and die.

Mr. W. W. Thomas, another of our students, has investigated wood rots in stone fruits with the surprising result of finding that some orchards have scarcely a sound tree, and that hardly any bearing orchard is free from wood decays. He found that the trouble is serious all over the main deciduous fruit regions, and that about one-half the bearing trees are already seriously infected, while almost all of the trees still sound are in a condition easily to become infected.

No practical remedy is known for decayed trees and almost nothing is being done to prevent infection. During the next decade the loss from deterioration and breaking down of trees now attacked must be very heavy. From this it appears that the subject should be carefully investigated and the facts made available to all the growers.

Symptoms of Wood Decay.—Wood decay is an insidious disease developing within the tree. It is not visible from the exterior until in some way the surface of the tree is broken, exposing the decayed or hollow interior. The rot starts in some area of dead bark or exposed wood, but drying protects the visible outer surface, so that it remains intact long after the rot is established and far advanced. Often there is sunburn and gumming of the decaying limbs, but nothing abnormal may be noticed until a large branch gives way under some unusual strain and the center is seen to be decayed. The tree may continue to bear well for some time, but finally breaks down.

There are several types of decay but the commonest is a light-colored rot, in which there is at first a slight darkening of the wood, after which it grows lighter in color and softer in texture until little is left except a very light powdery material. From the point of starting the rot spreads faster through the center of the trunk than laterally. Often decay works outward so slowly that the tree becomes hollow and remains standing for many years. But in the case of sappy bark of the apple Mr. Rodgers has observed that the outward spread of decay in the wood causes the death of the cambium and bark, giving rise to extensive dead areas or cankers, which enlarge each winter until the limb is killed or breaks off. On the dead limbs or parts, fungus bodies—brackets, conches, hoof fungi, punks, or toadstools—often appear. These fungus bodies are generally the spore-bearing part of the fungus which caused the rot of the wood. In some cases the fungus fruits are small or inconspicuous, and often well-advanced decay is found without any sort of fungus fruit. After some practice a trained mycologist can tell with considerable accuracy what fungus caused the rot by the color, texture, and other characteristics of the decaying wood. The final result is that one branch after another dies or is broken off while still vigorous. The whole tree may break off, but more generally one limb goes at a time until nothing but a worthless stump is left.

Cause of Wood Decay.—Wood decay is not caused by exposure to air and moisture. Neither is it directly caused by lack of thrift or old age of the trees. Untreated shingles on the side of a house weather gradually and would doubtless disappear in time, but there is no reason why the wood of a tree should deteriorate. Wood decay is due to the action of certain fungi which have the power of penetrating into the wood and digesting it. Not all fungi have this power, and not more than about a dozen species have been found causing serious harm in orchard trees in California. Of these the oyster-shell fungus (species of the genus *Polystictus* or *Coriolus*) does more harm than all the others combined. The fruits of this fungus somewhat resemble a small oyster shell, gray or brown with dark bands on the upper surface, and light-colored with vertical pores or minute tubes on the lower. There are several closely related species which, so far as observed, appear to act in very much the same way. Microscopic spores are formed in great numbers on the sides of the tubes and fall out, to be carried away by the wind or by other agents. The spores, if kept from direct sunlight or extreme drying, may live for weeks or even months, and grow when sufficient moisture is furnished. There is every reason to believe that cracks in exposed

pruning wounds are very favorable places for the spores to grow, if once they find their way into these places.

The fruiting bodies (sporophores or brackets) have remarkable resistance to drying. Taken from a woodpile in the San Joaquin Valley at the end of summer, and moistened, they have produced vigorous spores in a few hours. Specimens eaten by beetles until only shreds remained still produced spores when moistened. The fungus mycelium living in dead sticks will remain alive for several years if the wood is kept in a dry place. During one winter a single fruiting body may produce millions of spores, each one of which is capable of infecting a wound if it comes in contact with the wood and is kept sufficiently moist. Nevertheless part of the trees in an orchard usually remain free from rot for a time, although having large cracked wounds. This suggests that the spores do not happen to be carried to all wounds, or fail to grow successfully in them.

There are several fungi which are found occasionally associated with rot, and they doubtless cause it in most cases. Further study may considerably increase the list, but the principles of distribution and growth will apply rather closely to all, excepting the oak root fungus and a few other true parasites.

Nature of the Process.—Wood decay consists of a series of chemical changes brought about by the action of the fungus threads or mycelium, and is a process of digestion and absorption. Wood substance is composed of carbon, hydrogen, and oxygen, and, chemically, it rather closely resembles starch or sugar. Besides the wood substance proper there are some other materials in wood, such as the mineral constituents or ash. The digestion of wood consists in its change into some substance like sugar, which is then used by the fungus for food, the final result being that carbon and oxygen are combined to make carbon dioxid (carbonic acid gas) which escapes to the air, and the hydrogen is combined with oxygen to form water, which may easily be evaporated and disappear. Where the decay of wood is complete little is left except ash.

Manner of Infection.—The precise manner in which infection actually occurs is not easy to observe, since decay must develop to a certain stage before being recognizable. Small wounds and wounds not cracked seldom decay. Deeply cracked wounds, especially when large, generally are found with decay below them, and all evidence points to the cracks in exposed wood as the places where infection occurs. Evidently spores of wood-destroying fungi fall into the cracks. With wet weather the spores are kept moist until they grow and form mycelium, which penetrates into the wood and becomes

established. The stubs left in grafting-over large limbs are about the surest places of all for infection. A rather generous area of wood is exposed and this almost always cracks deeply. The cracks are usually so placed that wind-borne spores could easily fall into them, or, if deposited from the feet of birds or insects on the top of the stub, they would be beaten into the cracks by rain. Sometimes a stub heals over after decay has become established in the wood, and internal infection is only shown by the breaking of the tree or by the dying of some part of it and the emergence of fruits of the fungus. The danger of infection in any wound is not passed until the bark has completely healed over.

The manner in which fungus spores are carried to the tree wounds has not been determined; but wind, the feet of insects and birds, and various other agents, may play a part. Mr. Thomas has observed that there are often groups of trees affected with the same kind of rot fungus indicating that it has spread from an original source, or from tree to tree locally.

The oak root fungus causes rot of the wood of roots and the lower part of the trunk, after having killed the living root. It is confined rather closely to the roots and bases of trees. It freely attacks and kills living bark, differing in this respect from the ordinary wood rot fungi, which are powerless to penetrate through sound, living bark into the wood below.

Source of Infection.—The fungi which cause wood rot in the orchard can be found abundantly in the native growth, especially along wooded streams. Old orchards also become sources of infection. The destruction of sporophores in a well-isolated orchard would reduce the number of spores present, yet birds or insects might easily carry spores for several miles.

Susceptibility of Different Fruit Trees.—Observations suggest the following order of susceptibility of orchard trees to decay: Peach, cherry, apple, plum (including prunes), apricot, walnut, pear, olive, and citrus trees. Olive and citrus trees will probably become hollow without showing the more violent effects of rot, such as sappy bark of apple, but even they must be to a certain extent crippled.

Prevalence of Wood Decay in Orchards.—It is well recognized that some decaying trees occur in all sections and in nearly all orchards, especially of stone fruits and apples. The actual percentage of decayed trees can evidently be determined only by careful examination of large numbers of representative orchards, in which either every tree should be examined, or a certain number of trees taken in a way to represent the whole. A number of examinations of both kinds have

been made by Mr. W. W. Thomas for stone fruits. In the districts examined in central California it appears that nearly fifty per cent of all bearing stone fruit trees are positively infected with wood decay. Of the remainder not more than about two per cent are free from large cracked wounds which may already be infected or are in great danger of infection. Orchards which are not very old can be found in which every tree has decay. Grafted-over trees usually show a very high proportion of decay, frequently approaching a hundred per cent.

It might be supposed that, since moisture favors the growth of fungi and fungus spores, decay would be more prevalent in the moist coast sections than in the drier interior. From studies made to date, the reverse appears to be true. Fruiting bodies and spores are formed during the rainy season when, normally there is adequate moisture in all sections. Dry air in summer does not kill the sporophores of the worst of these fungi, but only suspends the production of spores. The more intense the heat and drying, the more sunburned and dead limbs will occur, and the more deeply the exposed wood will crack. Cracks in exposed wood appear to be the main starting points of rot. Accordingly our observation that the more trying the situation, the more prevalent wood rot becomes, appears to be logical.

No accurate estimates can be made of the annual loss to California orchards through decay of trees, since the comparative production of decaying and sound trees for the different varieties of fruit has never been carefully studied. Yet if we consider the shortening of the life of the tree, together with its original cost, the expense of planting and of care until the age of profitable production, and the decrease in bearing which we believe occurs when the tree becomes decayed, it is safe to say that wood rot in stone fruits and apples has reduced the production and increased the expense by a very large percentage. Professor Wickson states that the peach orchards in central and northern California are not old enough to mark the normal life of a peach tree, and the best authorities seem to agree that fifty or sixty years will not find the peach tree aged except by the entrance of decay into the wood. Yet the usual length of life of a peach orchard in California is not half this period.

Treatment of Infected Trees.—A tree with well established decay presents a difficult problem. Tree surgery methods may be employed, but, where decay has spread far through the center of a tree, the possibility of complete elimination is very doubtful. The expense of endeavoring to remove all decayed wood will usually make the operation impractical. The use of a cement filling in orchard trees

will rarely be advisable. Whatever will keep the decaying wood as dry as possible is probably the most promising procedure.

Some old wounds appear to have mild forms of decay. It would seem reasonable to treat such cases in the same way as sound wood, to prevent the entrance of fungi causing the more rapid rots. Where soft, active rot is established, sealing up the wound must tend to hasten its development by preventing drying.

Preventive Measures.—The greatest importance attaches to the proper training of the young tree. If too many branches are left in the framework, some of these crowd and must be removed later. Often the branch to be removed is in the center of the head, and a clean, well-drained cut is impossible. The picture of the tree when it is fully grown should be in the mind of the man shaping the young tree. The branches which form the framework should emerge from the main stem at such distances that they will not crowd in the mature tree, since they do not separate farther in the subsequent growth. It is difficult to grow a tree with sufficiently spaced framework branches, from a conventional nursery tree, treated in the usual way. It is not possible here to give specific directions for forming the framework of trees, nor is it probable that one system of pruning or another will be absolutely essential; however, such foresight should be exercised in any system that the subsequent removal of large limbs will not become necessary and that the splitting and breaking will be reduced to a minimum. Summer pinching and training should make it possible to reduce greatly the severity of the winter pruning.

Where limbs must be removed, close cutting is exceedingly important. Stubs even one-fourth inch longer than necessary may delay the time of healing for several years and accordingly increase the time of exposure to infection. Long stubs dry and crack more than short ones, and the cracks and exposed dead bark are the most favorable places for infection.

All attempts to prevent rot by treatment of the cuts have been abandoned in many good orchards, decay being found quite as active in painted cuts as in unpainted ones. We have observed that ordinary painting does not prevent the formation of large cracks; and these cracks are left untreated. *If decay is to be prevented, infection of wounds must be prevented,* and the following method is recommended:*

* These recommendations are not made on the basis of experiments by the writer, but on that of the safest and most reliable methods in tree surgery.

1. All cuts should be made close to the trunk.

2. Where limbs three-fourths of an inch or more in diameter must be removed, the cut surface should be immediately wet with a disinfectant solution (see below).

3. As soon as the surface is dry enough to hold paint well, a sealing paint should be applied, making a heavy coat over the surface (see below).

4. In September of each year all trees should be gone over, dead branches should be removed, all dead bark from sunburned and other injured areas should be carefully trimmed and scraped away, and wounds previously treated should be inspected. Treat all exposed wood, whether a new cut or a crack in a painted surface, with disinfectant, and, when dry, cover with sealing paint. A good sealing paint, applied in September, should last until the following summer, and, since spores must be in contact with wood in moist weather to cause infection, one treatment per year should protect trees in California.

For a *disinfectant,* corrosive sublimate, one part to one thousand parts of water, is recommended.

For a *sealing paint,* asphaltum, grade D, applied hot, is recommended. Asphaltum, thinned with benzine to make a paint to be applied without heating is said to give good results, but care should be used to get a coating of good body over the treated wood. Asphaltum has the advantage over ordinary lead and oil paints that it becomes plastic when warm and does not lose this property soon. Oil paints harden within a few days and are then liable to crack.

SUMMARY

Wood decay causes very serious losses in deciduous orchards in California.

It begins insiduously below dead areas and spreads extensively through the center of the tree, sometimes killing the branches but more frequently weakening them so that they break in times of unusual strain.

Decay of wood is not a natural result of old age or weakness but is due to the action of wood-destroying fungi.

The process of the destruction of wood by fungi is one of digestion and absorption. Where complete it leaves little besides ash, the chemical materials of the wood being split up and passing off as gases.

Infection evidently takes place through exposed wood and more specifically in large deep cracks. The oak root fungus forms an exception in that it is able to kill living bark and penetrate into the wood.

Fruit trees vary in their susceptibility to decay. The more resistant will doubtless grow for many years as hollow trees.

Statistics which have been gathered show that about fifty per cent of all bearing trees are infected with wood rot. The principal fruit regions all suffer, but apparently those with hot and trying summers somewhat more than the cool coast.

Treatments for decaying trees must follow tree surgery methods and are probably too expensive for general orchard application.

Prevention offers the most promise. Proper shaping of young trees to prevent breaking and the need of removing large limbs is the most important measure. Where large limbs must be removed, and wherever wood is exposed, a program for treatment is recommended, the features of which are:

1. Close cutting to accelerate healing.

2. Disinfecting with 1-1000 corrosive sublimate solution to prevent the growth of spores.

3. Sealing with hot asphaltum to prevent the introduction of spores into cracks in the wood.

4. Inspection of all trees at the end of summer, and the renewal of the disinfection and covering of all exposed wood to protect it from infection during the winter.

For additional study of the subject of this circular the following references are suggested:

Practical Tree Surgery, J. Franklin Collins. Reprint from the Yearbook of the United States Department of Agriculture for 1913. May be purchased from Superintendent of Documents, Washington, D. C. Price 10 cents.

Practical Tree Repair, etc., Elbert Peets. Published by McBride Nast and Company, New York, 1913. Price $2.00. Very highly recommended by some of our best tree pathologists. The necessity for renewing applications is emphasized.

Dressings for Pruning Wounds of Trees, A. D. Selby. Circular No. 126 Ohio Agricultural Experiment Station.

Tree Fillings and Wound Dressings for Orchard and Shade Trees, A. D. Selby. Circular No. 150 Ohio Agricultural Experiment Station, Wooster, Ohio.

Citrus Fruits, etc., pp. 226–229, J. Eliot Coit. Published by MacMillan Company, New York, 1915. Price $2.00 net.

Effect of Various Dressings on Pruning Wounds of Fruit Trees, G. H. Howe. Bulletin No. 396 New York Agricultural Experiment Station, Geneva, New York. Points out that certain dressings on wounds may delay healing.

DESCRIPTION OF PLATES

Plate I

Fig. 1.—Peach tree top worked to plum about five years before. The stub at the left has not healed over. It has become infected and sporophores of the oyster shell fungus (*Coriolus versicolor* [*Polystictus versicolor*]) are forming abundantly. Limb badly sunburned and rotted.

Fig. 2.—Sporophores of the same fungus showing the lower surface, which is composed of minute tubes or pores arranged vertically. Spores are formed in these tubes and fall out as very fine dust.

Fig. 3.—Part of the same group of sporophores seen in Fig. 2, showing the upper surface which is felty-hairy with smooth bands.

Photographs by Mr. W. W. Thomas.

PLATE 1

Plate II

Fig. 1.—Pruning cut well made about one year before, on French prune. Note the deep cracks where spores might easily lodge and be protected from drying long enough to germinate. Note also the callus just beginning to push out under the bark. It will take years to heal over this cut and, without treatment, the cracks are open to infection until covered over.

Fig. 2.—Cut well made at the top, but sloped out a little at the bottom. A heel has died and the callus has not yet covered this, while the top is nearly covered. Note the cracks in the exposed wood.

Fig. 3.—Cut well made, callus progressing nicely from all sides. Note the cracks. Infection may have occurred or may yet occur before the wound is covered. At *a* is a small cut. Note that it has no deep cracks. Orchardists agree that rot rarely starts from so small a wound.

Fig. 4.—Wound healed over. If infection has not already occurred, wood rot will not start at this place. Close cutting favors prompt healing over and thereby lessens the danger of infection.

Photographs by courtesy of Mr. Earl L. Morris, Horticultural Commissioner of Santa Clara County.

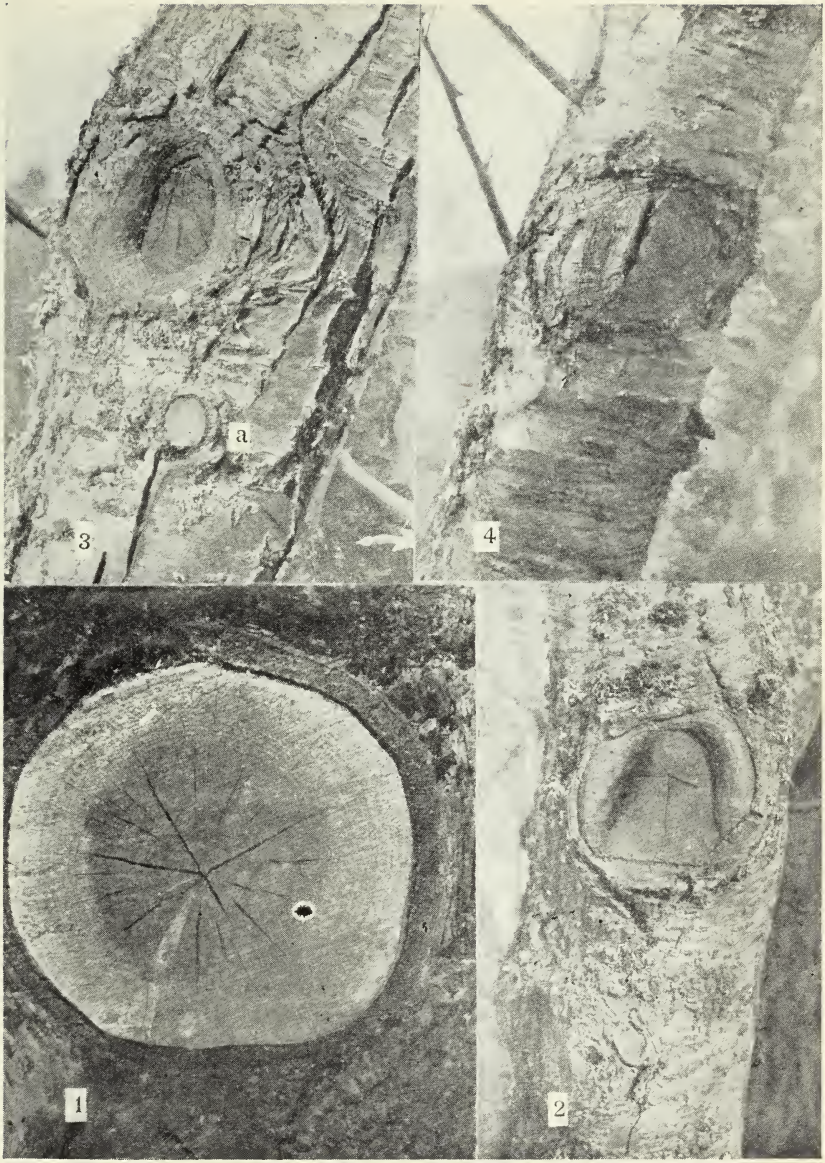

PLATE 2

STATION PUBLICATIONS AVAILABLE FOR DISTRIBUTION

REPORTS

1897. Resistant Vines, their Selection, Adaptation, and Grafting. Appendix to Viticultural Report for 1896.
1902. Report of the Agricultural Experiment Station for 1898–1901.
1903. Report of the Agricultural Experiment Station for 1901–03.
1904. Twenty-second Report of the Agricultural Experiment Station for 1903–04.
1914. Report of the College of Agriculture and the Agricultural Experiment Statoin, July, 1913–June, 1914.

BULLETINS

No.

168. Observations on Some Vine Diseases in Sonoma County.
169. Tolerance of the Sugar Beet for Alkali.
170. Studies in Grasshopper Control.
174. A New Wine-Cooling Machine.
177. A New Method of Making Dry Red Wine.
178. Mosquito Control.
184. Report of the Plant Pathologist to July 1, 1909.
185. Report of Progress in Cereal Investigations.
195. The California Grape Root-worm.
197. Grape Culture in California; Improved Methods of Wine-making; Yeast from California Grapes.
198. The Grape Leaf-Hopper.
203. Report of the Plant Pathologist to July 1, 1906.
207. The Control of the Argentine Ant.
208. The Late Blight of Celery.
211. How to Increase the Yield of Wheat in California.
212. California White Wheats.
213. The Principles of Wine-making.

No.

216. A Progress Report upon Soil and Climatic Factors Influencing the Composition of Wheat.
220. Dosage Tables.
225. Tolerance of Eucalyptus for Alkali.
227. Grape Vinegar.
230. Enological Investigations.
234. Red Spiders and Mites of Citrus Trees.
241. Vine Pruning in California. Part I.
242. Humus in California Soils.
244. Utilization of Waste Oranges.
246. Vine Pruning in California. Part II.
248. The Economic Value of Pacific Coast Kelps.
249. Stock Poisoning Plants of California.
250. The Loquat.
251. Utilization of the Nitrogen and Organic Matter in Septic and Imhoff Tank Sludges.
252. Deterioration of Lumber.
253. Irrigation and Soil Conditions in the Sierra Nevada Foothills, California.
254. The Avocado in California.
255. The Citricola Scale.
256. Value of Barley for Cows fed Alfalfa.

CIRCULARS

No.

65. The California Insecticide Law.
69. The Extermination of Morning-Glory.
70. Observations on the Status of Corn Growing in California.
76. Hot Room Callusing.
79. List of Insecticide Dealers.
80. Boys' and Girls' Clubs.
82. The Common Ground Squirrels of California.
83. Potato Growing Clubs.
87. Alfalfa.
91. Disinfection on the Farm.
92. Infectious Abortion and Sterility in Cows.
100. Pruning Frosted Citrus Trees.
101. Codling Moth Control in the Sacramento Valley.
106. Directions for using Anti-Hog-Cholera Serum.
107. Spraying Walnut Trees for Blight and Aphis Control.
108. Grape Juice.
109. Community or Local Extension Work by the High School Agricultural Department.
110. Green Manuring in California.
111. The Use of Lime and Gypsum on California Soils.

No.

113. Correspondence Courses in Agriculture.
114. Increasing the Duty of Water.
115. Grafting Vinifera Vineyards.
117. The Selection and Cost of a Small Pumping Plant.
118. The County Farm Bureau
119. Winery Directions.
121. Some Things the Prospective Settler Should Know.
122. The Management of Strawberry Soils in Pajaro Valley.
123. Fundamental Principles of Co-operation in Agriculture.
124. Alfalfa Silage for Fattening Steers.
125. Aphids on Grain and Cantaloupes.
126. Spraying for the Grape Leaf Hopper.
127. House Fumigation.
128. Insecticide Formulas.
129. The Control of Citrus Insects.
130. Cabbage Growing in California.
131. Spraying for Control of Walnut Aphis.
132. When to Vaccinate against Hog Cholera.
133. County Farm Advisor.
134. Control of Raisin Insects.
135. Official Tests of Dairy Cows.
136. Melilotus Indica.